SECTION II—CLAIMS

1-16. (Canceled)

17. (New) An apparatus comprising:

a diffractive grating formed in a substrate, the diffractive grating comprising:

a plurality of sub-gratings, each sub-grating having a pair of lateral edges and a periodic array of diffraction elements,

wherein the sub-gratings are positioned adjacent to each other with their lateral edges abutting or overlapping.

18. (New) The apparatus of claim 17 wherein each sub-grating has an amplitude, a spatial phase shift, a spatial period, and an optical phase shift ($A_i, x_i, \Lambda_i, \varphi_i$, respectively) introduced by a variation in a thickness of the substrate or by use of a superimposed phase mask, and wherein amplitude and phase parameters of each sub-grating are determined according to the equation

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$$a_i = \beta d \int_{m/(\beta\Lambda_i)-1/(2\beta d)}^{m/(\beta\Lambda_i)+1/(2\beta d)} \frac{T(\nu)}{F_i(\nu)} \exp\left(-j\pi(\nu\beta - m/\Lambda_i)(x_i^a + x_i^d)\right) d\nu$$

wherein $T(\nu)$ is the complex-value spectral transfer function, j is the square root of -1, m is a diffraction order, ν is a frequency of the input optical field, $F_i(\nu)$ is a spatial Fourier transform of an ith subgrating, $\beta = (\sin\theta_{in} + \sin\theta_{out})/c$, wherein c is the vacuum speed of light and θ_{in} and θ_{out} are angles between a direction of propagation of the input optacal field and the filtered optical field and a line normal to the subgrating, respectively, d is a subgrating width, A_i is determined by an amplitude of a_i, and x_i and φ_i are determined by a phase of a_i.

19. (New) The apparatus of claim 17 wherein the sub-gratings are positioned to apply a predetermined complex-valued spectral function to the input optical field.

20. (New) The apparatus of claim 19 wherein amplitudes of the sub-gratings control the predetermined complex-valued spectral transfer function.

21. (New) The apparatus of claim 20, further comprising an active device that dynamically reprograms each sub-grating to correspond to the predetermined complex-valued spectral transfer function.

22. (New) The apparatus of claim 17 wherein the sub-gratings have optical thicknesses, the optical thicknesses of each sub-grating being controlled by respective variations in thickness of the substrate.

23. (New) The apparatus of claim 17 wherein the sub-gratings are transmissive gratings.

24. (New) The apparatus of claim 17 wherein the sub-gratings are reflective gratings.

25. (New) The apparatus of claim 17 wherein the sub-gratings are positioned along a planar surface.

26. (New) The apparatus of claim 17 wherein the sub-gratings are positioned along a non-planar surface.

27. (New) An optical device that applies a specified complex-valued spectral filtering function to an input optical field and produces a filtered output of the input optical field that propagates in an output direction, the filtered output having a temporal structure essentially matching a reference optical waveform, the optical device comprising a plurality of sub-gratings, each sub-grating having a pair of lateral edges, wherein the sub-gratings are positioned adjacent to each other with their lateral edges abutting or overlapping to form a segmented grating, the segmented grating having a spectral transfer function predetermined according to the reference optical waveform.

28. (New) The optical device of claim 27 wherein the filtered output has a temporal structure essentially matching a cross-correlation of the input optical field with a reference optical waveform.

29. (New) The apparatus of claim 27 wherein the sub-gratings are transmissive gratings.

30. (New) The apparatus of claim 27 wherein the sub-gratings are reflective gratings.

31. (New) An optical communication system that multiplexes and demultiplexes a plurality of optical signals in accordance with a set of reference optical waveforms, each reference

optical waveform comprising a sequence of time slices, the communication system comprising:

a compound grating that includes at least a first segmented grating, the first segmented grating comprising a plurality of sub-gratings, each sub-grating having a pair of lateral edges and a periodic array of diffraction elements, wherein the sub-gratings are positioned adjacent to each other with their lateral edges abutting or overlapping, the first segmented grating having a spectral transfer function determined by sub-grating parameters $A_i, \varphi_i, x_i, \Lambda_i$ that are selected to match a predetermined reference optical waveform, the compound grating serving to multiplex multiple optical data streams by directing each optical data stream onto a specific segmented grating along its operative input direction, thereby producing an output beam encoded according to the reference optical waveform encoded in the first segmented grating; and

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a demultiplexer for demultiplexing a time-code multiplexed optical data stream from an OCDMA channel by directing the OCDMA channel along an input direction of a segmented grating encoded so as to direct the time-code multiplexed optical data stream in a time-code-specific output direction.

32. (New) The optical communication system of claim 31 wherein the sub-gratings are transmissive gratings.

33. (New) The optical communication system of claim 31 wherein the sub-gratings are reflective gratings.

34. (New) The optical communication system of claim 31 wherein the sub-gratings are aligned along a planar surface.

35. (New) The optical communication system of claim 31 wherein the sub-gratings are aligned along a non-planar surface.

36. (New) A method of applying a selected complex-valued spectral filtering function to an input optical field comprising:

providing a diffractive grating, the diffractive grating comprising a plurality of sub-gratings, each sub-grating having a pair of lateral edges and a periodic array of diffraction elements, wherein the sub-gratings are positioned

adjacent to each other with their lateral edges abutting or overlapping, the diffraction elements being selected to produce a complex-valued spectral filtering function; and

directing the input optical field to the diffractive grating.

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37. (New) The method of claim 35 wherein the diffractive grating is programmed to produce a predetermined temporal waveform.

38. (New) The method of claim 35 wherein the sub-gratings combine to produce a transfer function corresponding to a segmented grating having a transfer function corresponding to a complex-conjugate of a Fourier spectrum of a reference optical waveform, whereby an output optical field is produced in a predetermined direction and has a temporal structure determined by a cross-correlation of the reference optical waveform and the input optical field.